

Hydrologic budget of the ORW mitigation wetland, 2003

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Introduction

Understanding the hydrologic processes of mitigation wetlands is a fundamental key in effective ecosystem restoration and creation (Mitsch and Gosselink, 2000). One indicator of success for constructed wetlands is the fulfillment of the hydrology criterion (National Research Council, 1995). Hydrologic budgets, therefore, provide valuable information to meet restoration and creation goals.

The 3-ha mitigation wetland (the billabong) at the Olentangy River Wetland Research Park, constructed in the summer of 1996, is a freshwater, oxbow wetland that receives water from the Olentangy River. When the river level is higher than the wetland, water passively flows into the wetland through a check valve and eventually returns to the Olentangy River through a control weir. Previous hydrologic budgets from the beginning were presented in Wang et al. (1997), Johnson et al. (1998), Zhang and Mitsch (2000, 2001, 2002, 2003). This paper presents monitoring hydrologic budgets for 2003.

Methods

Location of the inflow and outflow of the billabong is shown in Figure 1. A twice-daily reading (staff gauges) was used to measure the surface water level of the Olentangy River and mitigation wetland. The following equation (Mitsch and Gosselink, 2000) was used to determine hydrologic budgets for the mitigation wetland:

$$\Delta V/\Delta t = Q_{in} + Q_{out} + G_{in/out} + P_{reci} - ET \quad (1)$$

where

$\Delta V/\Delta t$ = Change of water volume in wetland over time,

Q_{in} = Inflow,

Q_{out} = Surface outflow,

$G_{in/out}$ = Ground water exchange,

P_{reci} = Precipitation,

ET = Evapotranspiration.

All parameters (water inflows, outflows, water volume, precipitation and evapotranspiration, and groundwater) in equation (1) were calculated by the following equations (Wang et al., 1997):

Inflow

$$S_i = 1.8447ah^{1/2} \quad (2)$$

$$a = 0.7372D + 1.387D^2 - 0.39993D^3 \quad (3)$$

= cross sectional area, ft

$$L_r = 723 + L_s \quad (4)$$

where

D = water depth in pipe at weir box (ft)

= $\min(d, \max(0, L_r - 723.5))$

h = head causing flow (ft)

= $\max(0, \min(L_r - L_m, L_r - 0.6D - 723.5))$

L_r = river water level (ft above MSL)

L_s = staff gauge reading, ft

L_m = mitigation wetland water level (ft above MSL)

Outflow

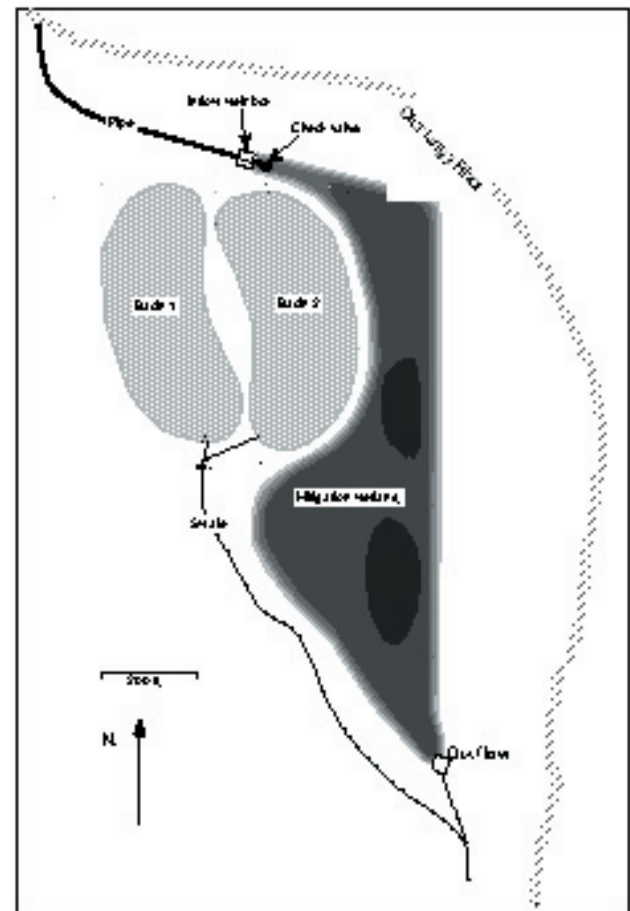


Figure 1. Location of the mitigation wetland at ORWRP.

$$S_0 = 10.16h_0^{1.436} \quad (5)$$

where

$$h_0 = \begin{cases} L_m - 724.2 & (L_m > 724.2) \\ 0 & (L_m < 724.2) \end{cases}$$

Surface water volume

Surface water volume was based on relationships between surface area, volume, and elevation. A detailed modeling approach was given by Wang et al. (1997). The following equation was used to calculate water volume (V , ft^3) of the mitigation wetland:

$$V = \begin{cases} 3.5873 \times 10^4 L_m - 2.5938 \times 10^7 & (0 < L_m < 723.5) \\ 6.8425 \times 10^9 - 1.9121 \times 10^7 L_m + 1.336 \times 10^4 L_m^2 & (723.5 < L_m < 727.0) \end{cases} \quad (6)$$

Daily precipitation and ET

Daily precipitation and evapotranspiration data were extracted from Ohio State University and the weather station (Mitsch et al., 1995) at ORWRP. Evapotranspiration data was used from the year 1999, because of absent data from both weather stations in 2003.

Groundwater exchange

The difficulties of evaluating groundwater seepage for the mitigation wetland were presented in Wang et al. (1997). The residuals, however, were used to estimate groundwater indirectly after balancing all other components of the hydrologic budgets (eqn. 1).

Results and Discussion

Figure 2 shows the hydroperiod of the wetland and the

Olentangy River for 2003. General water level trends of the billabong follow a pattern of high water levels in the early growing season, followed by drier conditions in late summer. This early flooding followed by summer drawdowns is typical of midwest marshes (Mitsch, 1992). There appear to be 4 independent flood events between January and June 2003 into the wetland. These flood events provide nutrients and introduce seeds and small organisms from across a watershed.

Figure 3 presents the relationships between surface water level (ft above MSL) and wet area (%) of the total mitigation wetland area, and wet periods (days) during two growing seasons (a: from April 20 to Oct. 20; and b: from May 1 to Oct. 31 during the period 2003). A summary of the wet days and wet area for the two growing seasons is given in Table 1. The wet periods are considerably longer than the hydrologic critical days which were given by National Research Council (1995) for wetland delineations and indicate that the design of this wetland was successful in establishing appropriate hydrologic conditions for a Midwest oxbow wetland.

Table 2 shows the annual hydrologic budgets for 2003. Daily values are given in Appendix A. By comparison, total inflow of 7 m/yr from the river in 2003 was essentially the same as the total inflow 6.8 m/yr from the river in 2002 but was lower than the inflows of 11.10 m/yr in 2000 and 9.25 m/yr in 1999 (Zhang and Mitsch, 2000, 2001, 2002).

References

Johnson, S.A., W.J. Mitsch and N. Wang. 1998. Hydrology of Ohio State University mitigation wetland for 1997. In: W.J. Mitsch (ed.), Olentangy River Wetland Research Park at The Ohio State University Annual

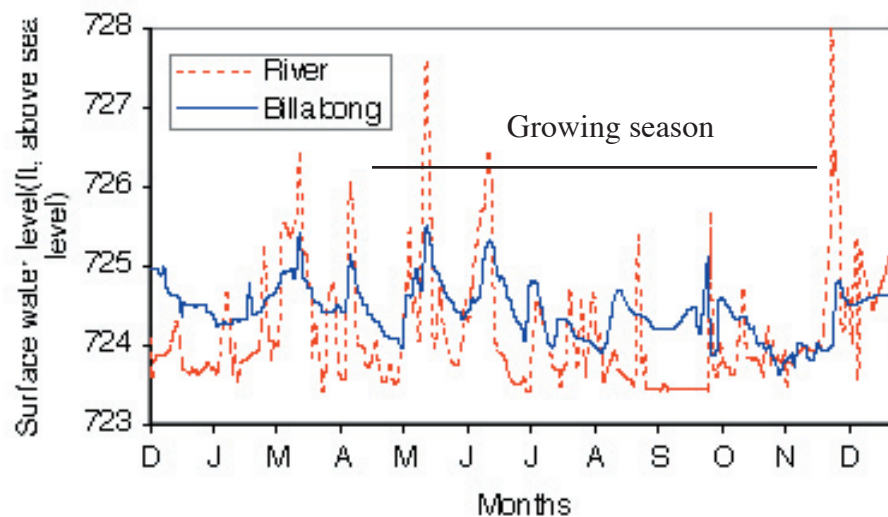


Figure 2. Daily surface water level (ft above sea level) in 2003

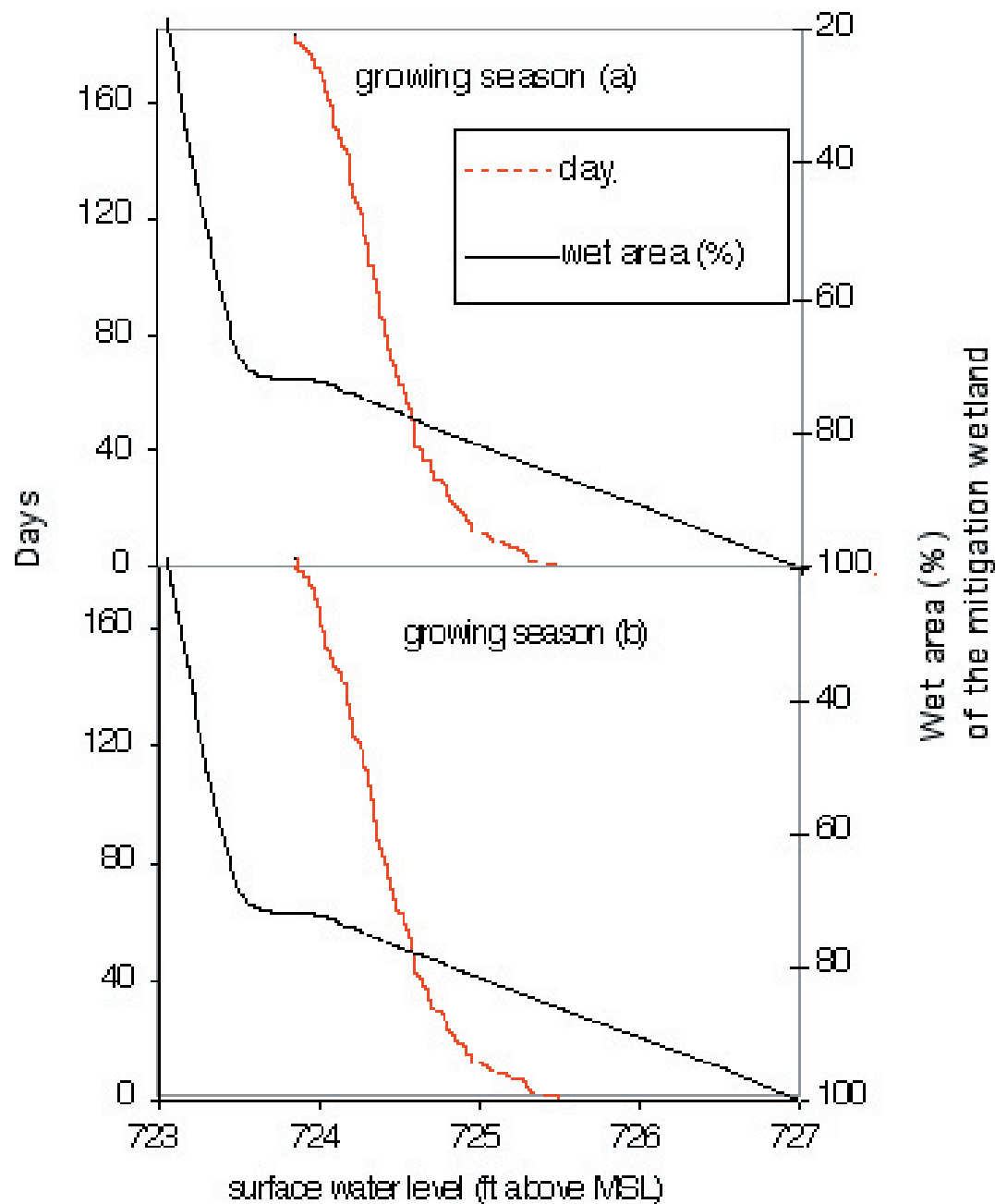


Figure 3. Relationship of surface water level to wet days and wet area (%) of the billabong during different definitions of the growing seasons (a: Apr 20 - Oct 19; b: May 1 - Oct 31), 2003.

Table 1. A summary of the wet days and wet area for the two growing seasons in 2003.

wet area%	68	72	82
growing seasons	wet days		
April 20 - October 19 2002	184	153	17
May 1 - October 31 2002	181	142	11

Table 2. Estimated annual hydrologic budgets, 2003

hydrologic parameters	2003 (m/yr)
Surface inflow from river	7.0
Surface outflow	--
Precipitation	3.4
Evapotranspiration	2.2

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Appendix A. Estimated daily hydrologic budgets for the billabong at ORWRP, 2003.

Date	River Level (ft)	Bill. level (ft)	Volume (ft ³)	Inflow (ft ³)	Outflow (ft ³)	Precipitation(ft ³)	ET (ft ³)
01/01/03	724.41	724.95	318461	0	0	0	0
01/02/03	723.58	724.20	318461	0	0	23808	740
01/03/03	723.59	724.95	318461	0	0	0	508
01/04/03	723.85	724.95	318461	0	0	0	584
01/05/03	723.85	724.95	318735	0	0	0	1166
01/06/03	723.85	724.91	307486	0	0	680	1502
01/07/03	723.85	724.86	296293	0	0	0	1773
01/08/03	723.85	724.97	323002	0	0	0	5482
01/09/03	723.85	724.93	312399	0	0	2041	3895
01/10/03	723.89	724.70	257441	0	0	0	455
01/11/03	723.92	724.63	242375	0	0	0	2265
01/12/03	724.03	724.63	240808	0	0	0	2661
01/13/03	724.15	724.62	240211	0	0	0	5617
01/14/03	724.27	724.62	239615	0	0	0	5349
01/15/03	724.27	724.61	237244	0	0	0	5530
01/16/03	724.01	724.56	224859	0	0	0	1821
01/17/03	723.79	724.34	173918	0	0	0	2265
01/18/03	723.69	724.51	214241	0	0	0	6023
01/19/03	723.66	724.50	210869	0	0	0	5646
01/20/03	723.64	724.50	210869	0	0	0	3471
01/21/03	723.63	724.50	210869	0	0	1360	5045
01/22/03	723.69	724.50	210869	0	0	0	5312
01/23/03	723.64	724.50	209871	0	0	0	903
01/24/03	723.67	724.47	204694	0	0	0	1837
01/25/03	723.62	724.50	210869	0	0	0	283
01/26/03	723.65	724.50	210869	0	0	0	2187
01/27/03	723.67	724.50	210869	0	0	0	1830
01/28/03	723.69	724.50	210869	0	0	2041	470
01/29/03	723.71	724.47	202835	0	0	1360	3900
01/30/03	723.78	724.40	188134	0	0	2721	6435
01/31/03	723.70	724.41	190131	0	0	0	4147

Date	River Level (ft)	Bill. level (ft)	Volume (ft ³)	Inflow (ft ³)	Outflow (ft ³)	Precipitation(ft ³)	ET (ft ³)
02/01/03	723.67	724.38	183786	0	0	0	1465
02/02/03	723.69	724.33	171771	0	0	1360	10143
02/03/03	723.62	724.22	145554	0	0	0	6372
02/04/03	723.70	724.24	150200	0	0	4762	1263
02/05/03	723.85	724.25	153033	0	0	2041	2385
02/06/03	724.26	724.25	153676	9810	6179	0	11197
02/07/03	724.43	724.27	158873	50367	10523	0	15110
02/08/03	724.65	724.25	152904	108663	5595	0	11948
02/09/03	724.49	724.24	151171	69605	4351	0	13284
02/10/03	724.00	724.24	151171	0	0	0	9616
02/11/03	723.62	724.28	160598	0	0	4762	1800
02/12/03	724.01	724.32	170128	0	0	0	2267
02/13/03	723.54	724.29	162813	0	0	0	8118
02/14/03	723.61	724.30	164787	0	0	0	13470
02/15/03	723.77	724.30	165899	0	0	0	13102
02/16/03	723.78	724.32	168569	0	0	680	2454
02/17/03	723.80	724.33	171244	0	0	0	1678
02/18/03	723.82	724.34	173922	0	0	2041	908
02/19/03	723.84	724.76	271848	0	0	0	2130
02/20/03	723.86	724.44	197785	0	0	2041	3815
02/21/03	723.87	724.38	181978	0	0	1360	5936
02/22/03	723.89	724.39	184670	0	0	0	10489
02/23/03	723.91	724.40	187176	0	0	48297	2275
02/24/03	723.99	724.40	187695	0	0	1360	4726
02/25/03	724.24	724.41	191103	0	0	680	15012
02/26/03	725.20	724.48	206959	225549	72311	0	10947
02/27/03	724.74	724.59	230791	75451	112406	0	12410
02/28/03	724.18	724.57	227836	0	0	0	8949
03/01/03	724.09	724.60	234311	0	0	0	8100
03/02/03	723.79	724.60	234311	0	0	0	8387
03/03/03	724.02	724.60	234311	0	0	0	3541
03/04/03	723.99	724.65	246529	0	0	0	4161
03/05/03	723.98	724.75	270536	0	0	0	7217
03/06/03	724.65	724.78	276364	0	0	5442	10202
03/07/03	725.52	724.90	306266	250078	265240	4762	9464
03/08/03	725.52	724.91	307621	250996	268267	0	2626
03/09/03	725.47	724.91	309715	233096	272966	4762	2840
03/10/03	725.42	724.92	311812	214690	277689	0	7957
03/11/03	725.36	724.93	313911	195772	282437	0	9950
03/12/03	725.42	724.93	314220	212491	283139	0	9020
03/13/03	725.52	724.84	291027	262333	231790	0	9891
03/14/03	725.65	724.95	318047	277499	291851	14965	11859
03/15/03	726.16	725.36	420046	308826	544647	0	11860
03/16/03	726.41	725.40	430904	347740	573529	0	12039
03/17/03	725.13	724.85	294209	138820	238680	0	2516
03/18/03	725.16	724.82	287964	154824	225208	0	3920
03/19/03	725.09	724.78	277755	141842	203624	0	7262
03/20/03	724.77	724.71	261557	43506	170578	3401	2415
03/21/03	724.56	724.71	260558	0	0	2041	3025
03/22/03	723.85	724.60	234449	0	0	2721	7672
03/23/03	724.24	724.54	221032	0	0	0	10124
03/24/03	724.13	724.53	216915	0	0	0	12375
03/25/03	723.86	724.51	213815	0	0	0	7947
03/26/03	723.60	724.49	208099	0	0	22448	16651
03/27/03	723.40	724.41	191065	0	0	680	14588
03/28/03	723.69	724.40	188450	0	0	0	9065
03/29/03	724.39	724.40	188054	0	0	0	9949
03/30/03	724.60	724.40	187695	73391	43879	31971	10834
03/31/03	724.69	724.40	187695	97214	43879	0	11719

Date	River Level (ft)	Bill. level (ft)	Volume (ft ³)	Inflow (ft ³)	Outflow (ft ³)	Precipitation(ft ³)	ET (ft ³)
04/01/03	724.76	724.41	190532	113666	47808	0	2519
04/02/03	724.59	724.45	199240	59418	60441	680	3157
04/03/03	723.82	724.49	208702	0	0	0	2350
04/04/03	723.61	724.46	201848	0	0	0	2355
04/05/03	723.56	724.40	187695	0	0	680	4907
04/06/03	723.56	724.40	187695	0	0	46936	4451
04/07/03	723.56	724.40	187695	0	0	0	2502
04/08/03	725.24	724.68	254444	207440	156565	26529	3079
04/09/03	726.01	725.13	362049	325079	396397	0	1810
04/10/03	725.78	725.03	338386	296145	339217	0	4850
04/11/03	725.41	724.96	320480	204069	297425	0	5019
04/12/03	724.46	724.82	287153	0	0	0	4866
04/13/03	724.01	724.69	256124	0	0	0	3726
04/14/03	723.97	724.62	238119	0	0	0	1683
04/15/03	723.98	724.55	221765	0	0	0	2238
04/16/03	723.95	724.50	210455	0	0	0	2802
04/17/03	723.73	724.49	208844	0	0	0	4003
04/18/03	723.71	724.38	183102	0	0	2041	2722
04/19/03	723.76	724.38	183228	0	0	680	1052
04/20/03	723.81	724.31	167075	0	0	0	4108
04/21/03	723.95	724.29	163622	0	0	55779	2871
04/22/03	724.03	724.29	161822	0	0	680	3013
04/23/03	723.74	724.28	160504	0	0	0	4258
04/24/03	723.58	724.22	145965	0	0	0	4205
04/25/03	723.53	724.17	136126	0	0	0	3038
04/26/03	723.51	724.12	125270	0	0	0	1430
04/27/03	723.53	724.10	120045	0	0	0	4984
04/28/03	723.68	724.09	116538	0	0	0	4738
04/29/03	723.74	724.08	115985	0	0	1360	4146
04/30/03	723.53	724.08	115431	0	0	680	3553
05/01/03	723.50	724.08	114877	0	0	9523	809
05/02/03	723.51	724.07	112505	0	0	26529	4043
05/03/03	723.65	724.03	104339	0	0	0	3234
05/04/03	723.82	723.99	94999	0	0	1360	809
05/05/03	723.97	723.95	87223	7022	0	1360	0
05/06/03	724.77	724.60	234311	80942	118724	144891	0
05/07/03	724.70	724.60	234311	55965	118724	0	1617
05/08/03	725.46	724.60	234311	276192	118724	98634	809
05/09/03	724.89	724.60	234311	116413	118724	0	1617
05/10/03	724.42	724.70	259145	0	0	62582	0
05/11/03	724.59	724.95	318515	0	0	102036	1617
05/12/03	724.40	724.91	308640	0	0	4081	4043
05/13/03	724.06	724.76	272397	0	0	0	38005
05/14/03	725.36	724.68	253828	246040	155365	0	0
05/15/03	726.77	725.03	338424	454995	339309	2041	0
05/16/03	727.48	725.44	442477	491738	604660	74826	3234
05/17/03	727.56	725.49	454046	496347	636130	0	8895
05/18/03	726.12	725.33	412460	306790	524668	10884	0
05/19/03	725.20	725.18	376780	29047	433022	0	0
05/20/03	723.97	724.94	316542	0	0	0	0
05/21/03	724.08	724.91	308180	0	0	145571	809
05/22/03	724.32	724.92	311216	0	0	0	0
05/23/03	724.72	724.79	280619	0	0	0	61454
05/24/03	724.48	724.80	282847	0	0	0	0
05/25/03	724.20	724.69	254545	0	0	0	1617
05/26/03	724.06	724.64	243881	0	0	17006	6469
05/27/03	723.93	724.60	233958	0	0	0	1617
05/28/03	723.81	724.57	227122	0	0	28570	7278

Date	River Level (ft)	Bill. level (ft)	Volume (ft ³)	Inflow (ft ³)	Outflow (ft ³)	Precipitation(ft ³)	ET (ft ³)
05/29/03	723.77	724.53	218617	0	0	2721	1617
05/30/03	723.74	724.44	197165	0	0	0	3234
05/31/03	723.74	724.42	192432	0	0	0	13746
06/01/03	723.74	724.40	188292	0	0	55099	0
06/02/03	723.96	724.37	181928	0	0	0	1617
06/03/03	724.03	724.31	166794	0	0	0	0
06/04/03	724.54	724.37	179687	61833	33340	93873	4852
06/05/03	724.31	724.40	188564	0	0	0	3234
06/06/03	724.29	724.42	192319	0	0	0	4043
06/07/03	724.59	724.49	208486	50281	74729	1360	3234
06/08/03	724.81	724.59	232892	95293	116166	3401	6469
06/09/03	725.04	724.52	215955	176246	86868	21768	4852
06/10/03	725.26	724.55	222929	237814	98647	0	5660
06/11/03	725.49	724.58	229926	280983	110869	0	5660
06/12/03	725.68	724.70	257379	314011	162308	12244	5660
06/13/03	725.71	724.95	318722	294655	293396	22448	8086
06/14/03	725.83	725.16	370522	282515	417372	8843	0
06/15/03	726.34	725.28	401816	353868	496917	1360	809
06/16/03	726.41	725.30	405884	363337	507483	0	2426
06/17/03	725.98	725.28	401254	287696	495459	1360	809
06/18/03	724.94	725.24	390177	0	0	0	3234
06/19/03	724.04	725.05	343289	0	0	0	3234
06/20/03	723.92	724.89	303189	0	0	0	6469
06/21/03	723.89	724.82	286054	0	0	0	12129
06/22/03	723.87	724.85	294339	0	0	0	16981
06/23/03	723.85	724.83	289928	0	0	0	0
06/24/03	723.80	724.71	259524	0	0	0	0
06/25/03	723.70	724.59	231022	0	0	0	809
06/26/03	723.61	724.58	228703	0	0	0	1617
06/27/03	723.53	724.47	203685	0	0	11564	1617
06/28/03	723.51	724.37	180292	0	0	0	0
06/29/03	723.49	724.32	169807	0	0	0	0
06/30/03	723.50	724.27	158182	0	0	0	1617
07/01/03	723.51	724.26	156091	0	0	0	13353
07/02/03	723.52	724.21	144225	0	0	0	18101
07/03/03	723.60	724.05	107843	0	0	0	18160
07/04/03	723.41	724.12	124734	0	0	0	17229
07/05/03	723.41	724.47	203688	0	0	34692	27722
07/06/03	723.41	724.79	280285	0	0	6802	15351
07/07/03	723.93	724.78	276401	0	0	48977	10526
07/08/03	724.28	724.79	279908	0	0	17006	21472
07/09/03	724.51	724.79	278772	0	0	28570	23882
07/10/03	724.50	724.66	247970	0	0	19047	20487
07/11/03	724.41	724.53	217612	0	0	8843	19836
07/12/03	724.32	724.40	187697	0	0	0	19389
07/13/03	724.23	724.27	158226	0	0	0	16688
07/14/03	724.13	724.14	129198	0	0	0	7229
07/15/03	724.04	724.02	100992	9306	0	0	19703
07/16/03	723.89	723.97	91087	0	0	28570	37340
07/17/03	723.73	723.97	91087	0	0	0	33795
07/18/03	723.70	724.03	104772	0	0	0	26875
07/19/03	723.68	724.18	138038	0	0	0	26109
07/20/03	723.66	724.32	168370	0	0	0	19418
07/21/03	723.45	724.33	171238	0	0	0	17661
07/22/03	723.69	724.32	168395	0	0	14965	18559
07/23/03	723.70	724.30	165624	0	0	2041	13146
07/24/03	724.03	724.30	165424	0	0	70064	23169
07/25/03	724.66	724.27	158647	107954	10320	0	15560
07/26/03	724.42	724.21	144633	58530	685	0	14148
07/27/03	724.18	724.15	130722	15389	0	0	15928

Date	River Level (ft)	Bill. level (ft)	Volume (ft ³)	Inflow (ft ³)	Outflow (ft ³)	Precipitation(ft ³)	ET (ft ³)
07/28/03	723.94	724.09	116913	0	0	9523	14678
07/29/03	723.71	724.09	116913	0	0	1360	14345
07/30/03	724.07	724.08	114621	0	0	0	14012
07/31/03	724.56	724.07	112332	99880	0	0	13679
08/01/03	724.09	724.06	110047	13002	0	0	9505
08/02/03	723.59	724.05	107764	0	0	0	8482
08/03/03	723.89	724.04	105483	0	0	44896	6351
08/04/03	724.22	724.02	103144	40508	0	31291	4168
08/05/03	724.47	724.01	99819	85677	0	240124	4428
08/06/03	724.64	723.99	95513	114443	0	4081	11065
08/07/03	724.19	723.97	90233	40674	0	0	10625
08/08/03	724.04	723.94	83989	19587	0	8163	6703
08/09/03	724.13	723.90	76790	36248	0	0	6640
08/10/03	723.81	723.90	75052	0	0	0	11849
08/11/03	723.55	723.93	82407	0	0	0	11212
08/12/03	723.59	724.01	98970	0	0	1360	17549
08/13/03	723.68	724.12	124994	0	0	0	12066
08/14/03	723.76	724.27	157670	0	0	0	16095
08/15/03	723.84	724.42	192345	0	0	0	9074
08/16/03	723.93	724.55	222219	0	0	8843	14087
08/17/03	723.85	724.64	244078	0	0	4762	21065
08/18/03	723.69	724.69	254762	0	0	0	30991
08/19/03	723.66	724.68	254100	0	0	0	20562
08/20/03	723.64	724.65	245442	0	0	0	18039
08/21/03	723.61	724.60	233953	0	0	0	15198
08/22/03	723.59	724.54	219858	0	0	0	7281
08/23/03	723.56	724.48	205860	0	0	0	6544
08/24/03	723.54	724.43	194765	0	0	0	5935
08/25/03	723.51	724.39	186528	0	0	0	6067
08/26/03	723.45	724.37	181114	0	0	0	8069
08/27/03	724.66	724.36	178500	95652	31849	0	8253
08/28/03	725.38	724.36	178500	260284	31849	124483	7451
08/29/03	724.16	724.36	178500	0	0	0	7358
08/30/03	723.61	724.35	176328	0	0	212914	7264
08/31/03	723.87	724.33	171992	0	0	193868	7171
09/01/03	723.43	724.30	165506	0	0	0	3234
09/02/03	723.42	724.27	158684	0	0	197269	10512
09/03/03	723.42	724.24	151885	0	0	49657	1617
09/04/03	723.42	724.21	145110	0	0	0	3234
09/05/03	723.42	724.19	140489	0	0	0	8895
09/06/03	723.42	724.18	138005	0	0	0	20215
09/07/03	723.42	724.18	137651	0	0	0	809
09/08/03	723.42	724.18	137651	0	0	0	0
09/09/03	723.49	724.18	137651	0	0	0	1617
09/10/03	723.49	724.18	137651	0	0	0	0
09/11/03	723.42	724.18	137651	0	0	0	35579
09/12/03	723.42	724.18	137651	0	0	0	0
09/13/03	723.42	724.18	138620	0	0	0	0
09/14/03	723.42	724.20	141144	0	0	0	12129
09/15/03	723.42	724.21	145227	0	0	0	5660
09/16/03	723.42	724.24	150880	0	0	2041	5660
09/17/03	723.42	724.27	158117	0	0	0	2426
09/18/03	723.42	724.31	166956	0	0	0	5660
09/19/03	723.42	724.35	176429	0	0	680	25876
09/20/03	723.42	724.39	185947	0	0	4762	4852
09/21/03	723.42	724.42	193291	0	0	0	4043
09/22/03	723.42	724.45	198199	0	0	0	26684
09/23/03	723.42	724.46	200654	0	0	159856	2426
09/24/03	723.42	724.46	200647	0	0	0	1617

Date	River Level (ft)	Bill. level (ft)	Volume (ft ³)	Inflow (ft ³)	Outflow (ft ³)	Precipitation(ft ³)	ET (ft ³)
09/25/03	723.42	724.45	198178	0	0	0	5660
09/26/03	723.42	724.17	134348	0	0	0	809
09/27/03	723.42	724.14	128122	0	0	61221	7278
09/28/03	723.42	724.37	180328	0	0	118361	0
09/29/03	723.42	724.63	240934	0	0	0	0
09/30/03	723.42	724.86	296990	0	0	1360	0
10/01/03	723.42	725.08	349802	0	0	0	1617
10/02/03	725.65	723.86	67167	309047	0	0	809
10/03/03	723.90	723.86	67167	8549	0	0	0
10/04/03	723.60	723.86	67167	0	0	3401	809
10/05/03	723.57	723.86	67167	0	0	680	0
10/06/03	723.71	724.56	224647	0	0	0	1617
10/07/03	724.00	724.60	234217	0	0	0	50134
10/08/03	723.82	724.58	230303	0	0	0	57411
10/09/03	723.75	724.53	216832	0	0	0	0
10/10/03	723.71	724.49	207508	0	0	0	6469
10/11/03	723.69	724.47	203861	0	0	0	35579
10/12/03	723.62	724.41	190685	0	0	0	1617
10/13/03	723.61	724.36	179400	0	0	0	0
10/14/03	723.62	724.32	169414	0	0	3401	52560
10/15/03	724.00	724.30	165807	0	0	106117	5660
10/16/03	724.05	724.34	174146	0	0	0	2426
10/17/03	724.61	724.35	176207	82976	29030	6122	809
10/18/03	724.68	724.35	176207	100956	29030	2721	0
10/19/03	724.00	724.35	175554	0	0	0	1617
10/20/03	723.83	724.27	158197	0	0	0	28301
10/21/03	723.84	724.21	144268	0	0	0	1617
10/22/03	723.81	724.20	142147	0	0	0	0
10/23/03	723.81	724.20	142147	0	0	0	0
10/24/03	723.82	724.09	117328	0	0	0	0
10/25/03	723.81	724.00	97667	0	0	0	0
10/26/03	723.75	724.00	97667	0	0	680	1617
10/27/03	723.66	724.00	97667	0	0	22448	809
10/28/03	723.60	724.00	97228	0	0	0	809
10/29/03	724.08	723.94	83579	26224	0	19047	2426
10/30/03	724.21	723.98	94261	42673	0	0	1617
10/31/03	723.75	723.99	94386	0	0	0	12938
11/01/03	724.03	723.85	65197	25414	0	0	0
11/02/03	723.83	723.80	54256	5278	0	14285	809
11/03/03	723.78	723.79	53148	0	0	0	0
11/04/03	723.86	723.63	18053	13082	0	0	0
11/05/03	723.77	723.60	12604	8165	0	0	0
11/06/03	723.79	723.73	39442	6285	0	0	1617
11/07/03	723.92	723.76	46184	17035	0	2721	0
11/08/03	723.46	723.79	52952	0	0	0	1617
11/09/03	723.76	723.83	59748	0	0	0	2426
11/10/03	723.76	723.85	65621	0	0	0	0
11/11/03	723.75	723.87	70372	0	0	0	0
11/12/03	723.73	723.71	34794	2945	0	76187	0
11/13/03	723.96	723.95	87664	4945	0	8843	0
11/14/03	723.91	724.00	97667	0	0	0	14555
11/15/03	723.92	724.00	97635	0	0	0	1617
11/16/03	723.96	723.99	96490	0	0	680	4043
11/17/03	723.96	723.99	94804	0	0	0	0
11/18/03	723.97	723.91	77590	12308	0	0	3234
11/19/03	723.93	723.80	54256	15967	0	19727	0
11/20/03	723.91	723.80	54256	13940	0	7483	0
11/21/03	723.91	723.80	54256	14283	0	0	0
11/22/03	723.92	723.89	73048	8195	0	0	1617
11/23/03	724.01	724.00	97667	6272	0	0	7278
11/24/03	724.03	724.00	97053	10961	0	0	0

Date	River Level (ft)	Bill. level (ft)	Volume (ft ³)	Inflow (ft ³)	Outflow (ft ³)	Precipitation(ft ³)	ET (ft ³)
11/25/03	723.92	723.92	79464	0	0	11564	0
11/26/03	724.20	723.91	78821	46115	0	0	0
11/27/03	724.59	723.92	79931	106216	0	0	0
11/28/03	724.99	723.93	82796	182035	0	31971	3234
11/29/03	725.38	723.95	86415	261204	0	37413	809
11/30/03	728.53	723.97	90793	658690	0	0	3234
12/01/03	726.17	723.99	95307	392199	0	0	0
12/02/03	726.43	724.73	265988	430021	179464	0	0
12/03/03	725.92	724.79	280549	351184	209477	0	0
12/04/03	725.71	724.80	281178	317276	210799	0	0
12/05/03	724.16	724.70	258334	0	0	2041	0
12/06/03	724.18	724.60	233332	0	0	38093	0
12/07/03	724.46	724.57	227493	0	0	0	0
12/08/03	724.72	724.52	215638	83718	86343	0	0
12/09/03	724.49	724.50	210869	0	0	0	1617
12/10/03	724.00	724.50	210869	0	0	0	0
12/11/03	724.88	724.50	210927	133114	78640	42175	0
12/12/03	725.30	724.51	212843	245839	81749	0	0
12/13/03	723.55	724.52	215616	0	0	0	0
12/14/03	725.17	724.53	218303	215316	90787	0	0
12/15/03	725.05	724.54	220980	174590	95315	1360	0
12/16/03	724.92	724.55	223661	134060	99908	0	0
12/17/03	724.79	724.57	226346	93450	104566	16326	0
12/18/03	724.66	724.58	229034	49626	109289	0	0
12/19/03	724.53	724.59	231725	0	0	0	0
12/20/03	724.43	724.60	234028	0	0	0	0
12/21/03	724.49	724.60	234311	0	0	0	0
12/22/03	724.57	724.60	234311	0	0	0	6469
12/23/03	724.65	724.60	234311	40308	118724	0	2426
12/24/03	724.73	724.60	234311	68928	118724	20407	1617
12/25/03	724.81	724.60	234311	94133	118724	0	2426
12/26/03	724.89	724.60	234311	118507	118724	0	0
12/27/03	724.97	724.60	234311	142713	118724	0	0
12/28/03	725.05	724.60	234311	166948	118724	0	0
12/29/03	725.13	724.60	234311	191230	118724	0	1617
12/30/03	725.21	724.60	234311	215489	118724	37413	1617
12/31/03	724.00	724.60	234311	0	0	2041	0